Japanese Patent Laid-Open No. 08-077961
Publication Date: March 22, 1996
Application No.: Hei 06-236092
Filing Date: September 6, 1994
Int. Class. No.: H01J 37/317; H01L 21/265
Inventor: Koshizuka Yasuo
Applicant: Casio Computer Co, Ltd.
Specification
(54) Title of Invention: ION DOPING METHOD AND APPARATUS THEREOF
(57) Abstract
[Objective]

It is an object of the present invention to offer an ion doping method and an apparatus which are especially effective for a large-sized substrate used for a large-sized LCD device by analyzing and extracting only required ions and implanting them on a substrate accurately and uniformly.

[Aspect]

The process according to the present invention comprises an ion drawing process for drawing ions by applying an extraction voltage to two or more sorts of ions from an ion source chamber 13; a selected ion extracting process for extracting only the selected ion 15 by passing various kinds of ions which are drawn in the drawing process through an ion analyzing portion 20; and an ion accelerating process for applying an accelerating voltage to the selected ion 15 which is extracted in the selected ion extracting process and making it toward a substrate; and the ion analyzing portion 20 is provided with an ion drawing gate 21. The apparatus according to the present invention comprises an ion selecting gate 23 which extracts only the selected ion 15 through the prescribed magnetic field out of two or more kinds of ions which passes through the gate, and the accelerating voltage is applied between this ion selecting gate 23 and an accelerating electrode 30.

[Claims]

[Claim 1] An ion doping method wherein an ion source gas is introduced into an ion source chamber and is ionized, subsequently only the selected ion which is extracted by ion analysis out of two or more kinds of ions having respectively peculiar mass and electric charge is implanted on a substrate comprising:

an ion drawing process for drawing ions by applying an extraction voltage to said selected ion and two or more kinds of non-selected ions from an ion source chamber;

a selected ion extracting process for extracting only said selected ion by passing these ions which are drawn in said drawing process through an ion analyzing portion; and

an ion accelerating process for applying an accelerating voltage to said selected ion which is extracted in said selected ion extracting process and making it toward a substrate.

[Claim 2] An ion doping apparatus wherein an ion analyzing portion which extracts the selected ion out of various kinds of ions generated by performing an ionizing treating on an ion source gas in an ion source chamber and implants it into a substrate, comprises a first electrode for drawing by applying an extraction voltage to various kinds of ions, and a second electrode for guiding and extracting only said selected ion out of various kinds of ions which are passed through said first electrode by which said extraction voltage is applied between this first electrode according to a set-up magnetic field, and a third electrode for accelerating said selected ion by applying an accelerating voltage between the second electrode of the ion analyzing portion is provided.

[Claim 3] The ion doping apparatus according to claim 2 wherein said ion analyzing portion comprising:

an ion drawing gate which has a large number of ion passing ports and is provided as said first electrode for applying an extraction voltage to these various kinds of ions;

an ion selecting gate which has a large number of slits which are provided in the lower course on the exit side of said ion passing port and on which a

curved-surface is formed for guiding only the selected ion out of said various kinds of ions passing through said ion drawing gate to the inside according to a set-up magnetic field, and is provided as said second electrode for applying an extraction voltage between said ion drawing gate; and

an accelerating electrode which is provided as said third electrode is provided in the lower course on the exit side of said slit, and the accelerating voltage is applied between the ion selecting gate.

[Claim 4] The ion doping apparatus according to claim 3 wherein a plurality of said ion selecting gate are provided on the upper course side and the lower course side in said ion analyzing portion.

[Detailed Description of the Invention]

[Industrial Field of Application]

The present invention relates to an ion doping method and an apparatus thereof which are suitable for forming a thin film of a substrate.

[Related Art]

For example, in an active matrix type liquid crystal display device, a thin film transistor is provided in matrix shape on a substrate. In the manufacturing process thereof, there is a process for doping an impurity of phosphorous ion and the like to a source region and a drain region of a semiconductor layer. Fig. 4 shows schematically the conventional example of an apparatus which is used for ion doping. An apparatus 1 has an introducing port 2 of low-pressure gas which will be used as an ion source, from which the gas is introduced and is made to be a plasma state by applying a voltage, for example, with a high-frequency power source in an ion source chamber 3. The ion formed in the ion source chamber 3 is drawn by applying an extraction voltage with an extraction power source 4, then, the drawn ion is accelerated by applying an accelerating voltage with an accelerating power source 5, and then, is implanted on the surface of a substrate 6. In the apparatus 1, extraction electrodes 7 and 8 of a couple of positive and negative polarities which are connected to an extraction power source 4 are provided on the

upper course side in the ion circulating direction, and an accelerating electrode 9 connected to the accelerating power source 5 is provided on the lower course side.

In such an ion doping method which is known conventionally, ions which need not to be doped on a substrate, such as phosphine gas (two or more kinds of fragment ions caused by decomposition of PH_3 gas) of an ion source and an impurity ion caused by the impurity in the ion source chamber 3, are mixed in ions to which voltages by the extraction power source 4 and the accelerating power source 5 are applied in order. Therefore, it is inconvenient that these unspecified ions are implanted to the substrate 6 together with the necessary ions. Accordingly, in order to solve such inconveniences, it is known that an ion analysis system is built in an apparatus so that only the necessary implanting ion is selected and is implanted. As a specific example, a mechanism of ion analysis system is provided on the lower course side of aforementioned extraction electrodes 7 and 8 and the accelerating electrode 9. That is to say, the method is that ions containing unnecessary ions are drawn by applying the extraction voltage, and are made to be passed through the analysis system after being accelerated by applying the accelerating voltage, so that only the required mass ions are guided in the formed magnetic field and are implanted the substrate 6.

[Problems that the Invention is to Solve]

In the respect that only the necessary ion is taken out through the ion analysis system, the inconvenience in the method of Fig. 4 can be solved. However, in case of the ion doping method having this analysis system, the following problems to be solved remain. In order to implant the required ions on a substrate effectively, it is preferable that the ions are accelerated within the necessary range. However, by passing all the ions accelerated once through the analysis system, the acceleration is reduced. It is necessary to make a strong magnetic field correspondingly so as not to reduce the acceleration, consequently there is a fault which causes enlargement of the whole apparatus containing an electric system conjointly with the consumption of large electricity. The purpose of the present invention is to solve the conventional problem, and to offer an ion doping method and an apparatus which are effective for a large substrate especially used for a large LCD device by

obtaining an accurate and uniform film on a substrate by analyzing and extracting only the required ions.

[Means for Solving the Problems]

In order to attain this purpose, an ion doping method by the invention according to claim 1 is that an ion source gas is introduced into an ion source chamber and is ionized, subsequently only the selected ion which is extracted by ion analysis out of two or more kinds of ions having respectively peculiar mass and electric charge is implanted on a substrate comprising:

an ion drawing process for drawing ions by applying an extraction voltage to said selected ion and two or more kinds of non-selected ions from an ion source chamber;

a selected ion extracting process for extracting only said selected ion by passing these ions which are drawn in said drawing process through an ion analyzing portion; and

an ion accelerating process for applying an accelerating voltage to said selected ion which is extracted in said selected ion extracting process and making it toward a substrate.

Besides, an ion doping apparatus by the invention according to claim 2 is that an ion analyzing portion which extracts the selected ion out of various kinds of ions generated by performing an ionizing treating on an ion source gas in an ion source chamber and implants it into a substrate, comprises a first electrode for drawing by applying an extraction voltage to various kinds of ions, and a second electrode for guiding and extracting only said selected ion out of various kinds of ions which are passed through said first electrode by which said extraction voltage is applied between this first electrode according to a set-up magnetic field, and a third electrode for accelerating said selected ion by applying an accelerating voltage between the second electrode of the ion analyzing portion is provided.

Moreover, according to the invention of claim 3, an ion analyzing portion comprising:

an ion drawing gate which has a large number of ion passing ports and is provided as said first electrode for applying an extraction voltage to these various

kinds of ions;

an ion selecting gate which has a large number of slits which are provided in the lower course on the exit side of said ion passing port and on which a curved-surface is formed for guiding only the selected ion out of said various kinds of ions passing through said ion drawing gate to the inside according to a set-up magnetic field, and is provided as said second electrode for applying an extraction voltage between said ion drawing gate; and

an accelerating electrode which is provided as said third electrode is provided in the lower course on the exit side of said slit, and the accelerating voltage is applied between the ion selecting gate.

Besides, according to the invention of claim 4, a plurality of said ion selecting gates can be provided on the upper course side and the lower course side in the ion analyzing portion.

[Action]

In the ion doping method by the invention according to claim 1, two or more kinds of ions are applied by an extraction voltage and are drawn from the ion source chamber in the ion drawing process, and only the selected ion is extracted by passing various kinds of ions drawn in the drawing process through the ion analyzing portion in the next selected ion extracting process. After extraction of such selected ion, the selected ion is applied by the accelerating voltage and is made to be toward the substrate in the ion accelerating process. In the conventional method, before the selected ion is extracted in the ion analyzing portion, all of the selected ion and other two or more kinds of ions are accelerated so that the selected ion is extracted in the ion analyzing portion. That is to say, in order to extract the selected ion out of the accelerated ions, it is necessary to form a strong magnetic field in the ion analyzing portion. By this difference, magnetism formation of the electromagnetic field in the ion analyzing portion is mitigated in the invention. In the ion doping apparatus according to claims 2 and 3, because an accelerating electrode as the third electrode is provided on the lower course of the exit side of the ion analyzing portion comprising the ion drawing gate of the first electrode and the ion selecting gate of the second electrode, it is enough to accelerate only the

selected ion which is extracted. The magnetism formation in the ion analyzing portion is mitigated, consequently increase of electric output is restrained, and enlargement of apparatus containing an electric system is restrained. Besides, by providing an ion drawing gate, rectification of unspecified various kinds of ions can be performed. Moreover, as the invention according to claim 4, in the ion analyzing portion, if a plurality of ion selecting gates are provided on the upper course side and the lower course side, the selected ion is passed in order through several slits on which curved-surfaces are formed, so that the extraction precision of the needed ion is increased.

[Embodiment]

Hereinafter, one embodiment of an ion doping method and an apparatus by the present invention is explained referring to the drawings. Fig. 1 shows a front cross sectional view of a doping apparatus of the embodiment. An apparatus 10 has an ion analyzing portion 20 of the important portion of the invention. A large number of ion passing ports 21a are provided at the horizontal single line in an ion drawing gate 21 as the first electrode which constitutes this ion analyzing portion 20. Besides, an ion selecting gate 23 as the second electrode is provided on the lower course of the exit side of the ion passing port 21a of the ion drawing gate 21, and a large number of slits 24 which are formed to have a curved-surface having a prescribed curvature are provided in a horizontal single line in this ion selecting gate 23. In each slit 24, a magnetic field of the set-up magnetism can be formed by energization to an electromagnetic coil (not shown) which is provided in the periphery. That is to say, the required magnetic field is formed by applying an extraction voltage between the ion drawing gate 21 of the first electrode mentioned above as an extraction voltage, and only the selected ion from various kinds of ions passing through the ion drawing gate 21 can be extracted by being guided on a curved-surface portion 25 of the slit 24 which has a curvature corresponding to the direction of the formed magnetic force line. Moreover, with respect to the ion analyzing portion 20 mentioned above, the accelerating electrode 30 which is provided as the third electrode is provided on the lower course of the exit side of the slit 24 of the ion selecting gate 23, and the accelerating voltage is applied

between the ion selecting gate 23 of the second electrode.

The detail structure of each portion of the apparatus, as shown in the drawings, are that an introducing port 12 for introducing an ion source gas is provided on the upper end side of a housing 11 which is a main portion of the apparatus, and that the inside is an ion source chamber 13 for forming a plasma state by applying the electric energy, for example, with a high frequency power source and the like to an introducing gas. An ion analyzing portion 20 is provided on the lower course of the exit side of the ion source chamber 13. In the ion analyzing portion 20, an ion drawing gate 21 is provided, which is such the first electrode in this invention constituting an extraction electrode. A large number of ion passing ports 21a are provided horizontally in the form of intersecting perpendicularly with the travelling direction of ion in this ion drawing gate 21, from which two or more kinds of non-selected ion 14 and the selected ion 15 to be implanted which are generated from the ion source gas by the plasma state in the ion source chamber 13 can be passed through. That is to say, as explained below, by applying the "extraction voltage" from the extracting power source 22 between the ion selecting gate 23 as the second electrode, two or more kinds of ions which are generated in the ion source chamber 13 are guided, and are made to be passed through each ion passing port 21a of the ion drawing gate 21.

Moreover, on the lower course on the exit side of the ion passing port 21a of the ion drawing gate 21, the ion selecting gate 23 is provided which is mostly prolonged in parallel with it. As shown in enlarged Fig. 2, a large number of curved slits 24 are provided at the horizontal single line in the ion selecting gate 23. The slit 24, of which central axis is formed to have the prescribed curvature radius, is surrounded by an inhibition step portion 26 formed by a curved-surface portion 25, a curved line (the curvature is made to be small in practice) which has a different curvature from that of the curved-surface portion 25 and a straight line. Besides, it is not shown in the drawings, electromagnetic coils are provided in the individual slits 24, or in the periphery which surrounds all of the slits 24. The required electromagnetic fields can be formed on the slits 24 individually by energization to these electromagnetic coils. In order to set the direction and the strength of the magnetic force line by magnetic fields formed in response to a

curvature of the curved-surface portion 25 in the slit 24 and a kind of the selected ion 15, it is possible to adjust the electric current energized to the electromagnetic coil in advance. The voltage of electromagnetic coil can be the extraction voltage from the extraction power source 22 mentioned above in the embodiment.

The ion which passes through the curved-surface portion 25 of the slit 24 is the selected ion 15, and in order to extract such selected ion 15, the determination of the magnetic force line of magnetic field and the curvature of the curved-surface portion 25 can be explained by the following expression in the relation of the mass and the electric charge of the selected ion 15 which is the extraction target.

$$B = 1/R \cdot \sqrt{2mV/q} \quad \ldots (1)$$

In the (1) expression here, B is the magnetic field strength expressed with the flux density, R is the curvature radius of the slit curved-surface portion 25 mentioned above, m is the mass of the selected ion as the extraction target, V is the extraction voltage mentioned above as a voltage of electromagnetic coil, and q is the electric charge of the selected ion 15. That is to say, in case of extracting the selected ion 15 with the mass-m and the electric charge-q as a target, the "extraction voltage" by the extraction power source 22 is adjusted so as to obtain the strength B of the magnetic field corresponding to the (1) expression.

As mentioned above, the ion analyzing portion 20 is mainly composed by the ion drawing gate 21 and the ion selecting gate 23. Corresponding to the ion analyzing portion 20, the accelerating electrode 30 as the third electrode in this invention is provided on the lower course of the slit exit side of the ion selecting gate 23. The accelerating voltage from the accelerating power source 28 is applied to the accelerating electrode 30 between the ion selecting gate 23 of the second electrode. Needless to say, this accelerating voltage is applied only to the extracted selected ion 15 mentioned above. When the accelerating voltage is set larger than the extraction voltage mentioned above, it is effective to accelerate the selected ion 15 efficiently. On the further lower course side of the accelerating electrode 30, a substrate 16 which is a target for implantation to the prescribed position is set.

Next, an doping method by using an ion doping apparatus of the embodiment and its operation are explained. The ion source gas is introduced from the introducing port 12 of the housing 11. In the ion source chamber 13, the introducing gas is applied with the electric energy with the high frequency power source and the like so that the plasma state is made. In the ion drawing process, to the selected ion 15 and the non-selected ion 14, the prescribed extraction voltage is applied by the extraction power source 22 between the ion drawing gate 21 and the ion selecting gate 23 in the ion analyzing portion 20. Accordingly, the selected ion 15 and various kinds of non-selected ions 14 are drawn from the ion source chamber 13, and pass through each passing port 22 of the ion drawing gate 21.

In the next selected ion extracting process, all of the selected ion 15 and various kinds of non-selected ions 14 which are drawn by passing through the ion passing port 21a go to the ion selecting gate 23 uniformly. In the ion selecting gate 23, the extraction voltage is applied to electromagnetic coils by using the extraction power source 22, and magnetic fields with strength B corresponding to them are formed in each slit 24. Because the selected ion 15 and various kinds of non-selected ions 14 have respectively peculiar mass and electric charge, something not to be suitable for principle such as the magnetic force line direction of the formed magnetic field in the slit 24 collides with an inhibition step 26, and stops advancing there. That is to say, when the mass/electric charge of the selected ion 15 is m_0/q_0, it passes along with the curved-surface portion 25 of the slit 24. When m_1/q_1 of the non-selected ion 14 is larger than m_0/q_0 of the selected ion 15, it collides with the ion selection gate 23 without bending in the slit 24. When m_1/q_1 is smaller than m_0/q_0, it bends too much in the slit 24 so that it collides with the ion selecting gate 23.

The speed of the selected ion 15 which passes through the ion analyzing portion 20 is increased further in the following ion accelerating process. The prescribed accelerating voltage is applied by the accelerating power source 28 between the ion selecting gate 23 and the acceleration electrode 30 of the ion analyzing portion 20. By receiving this accelerating voltage, the selected ion 15 which passes through each slit 24 of the ion selecting gate 23 is accelerated further, and is implanted on the substrate 16 which is set and standing by in the lower side

as it is.

As the conventional method, compared with accelerating by applying the accelerating voltage to the selected ion 15 containing unspecified various kinds of non-selected ions 14 before the ion analyzing system, because it is enough to be applied to only the previously extracted selected ion 15, it is effective in a facility of electric system and in efficiency, and the characteristic of the substrate 16 which is implanted can be also improved.

In addition, in this invention, in order to improve further the extraction precision of the selected ion to be implanted, it is also possible to be a structure of the ion analyzing portion 20 as shown in Fig. 3. That is to say, one or more steps of almost the same mechanism as the ion selecting gate 23 mentioned above as the second electrode are increased further on the lower course side. The increased ion selecting gate 40 has the deflection direction of the slit curved-surface portion 25 of the ion selecting gate 23 reverse to the previous step. Accordingly, ions can be extracted by several steps, so that the extraction precision can be improved. The extracting and accelerating voltages are applied to the ion selecting gate 40 of the rear step in the same way as the gate 23 of the previous step. According to the control, it is possible that the accelerating efficiency is considered by setting the applying voltage to the ion selecting gate 40 of the rear step higher than that to the gate 23 of the previous step. Thereby, the applying voltage to each gate is generally kept low in advance, and the acceleration can be performed by increasing the voltage step by step. Besides, in the invention mentioned above, the direction of electric field of the power sources 22 and 28 can be adjusted according to the polarity of the selected ion to be implanted.

[Effects of the invention]

As explained above, by the ion doping method and the apparatus by the invention according to claims 1 to 4, the conventional method needs to form the strong magnetic field in the mass analyzing system in order to apply the extraction voltage and the accelerating voltage to two or more kinds of ions containing the selected ion to be implanted at the early stage and extract the specific ion out of all the accelerated ions by the mass analyzing system, to the contrary, in this invention,

the selected ion is extracted first in the ion analyzing portion, consequently only the extracted selected ion is accelerated. Therefore, the burden of electricity in forming the electromagnetic field in the ion analyzing portion is mitigated, and the extraction precision and the quantity of ions to be implanted into the substrate are high and accurate.

[Brief Description of the Drawings]

[Fig. 1] A front cross sectional view of an apparatus of an embodiment in which an ion doping method by this invention is adopted.

[Fig. 2] An enlarged oblique view of a main portion in an ion doping apparatus of an embodiment.

[Fig. 3] A cross sectional view of one portion showing other embodiment of this invention as a variation of an apparatus of the embodiment mentioned above.

[Fig. 4] A schematic cross sectional view showing the conventional ion doping apparatus.

[Description of the Reference Numerals and Signs]

13 ion source chamber
14 non-selected ion
15 extracted selected ion
16 substrate
20 ion analyzing portion
21 ion drawing gate (a first electrode)
21a ion passing port
22 extraction power source
23 ion selecting gate (a second electrode)
24 slit
28 accelerating power source
30 accelerating electrode (a third electrode)
40 ion selecting gate of the rear step